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Consideration of Uncertainties and Risks in the Building Process of Multifunctional Harbor Transshipment Complex

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The present paper discusses types of management uncertainty exemplified by the case study of a project of building a multifunctional harbor transshipping center. The analysis is based on the ideas and works of I. Fischer. The paper shows that the role of project management actors substantially influences risks and that change of the actor's role leads to minimization of risks and elimination of uncertainty about project realization time. To analyze project risks the authors develop a complex model of risk assessment based on analysis of probability and impact level of undesired events. Probability of undesired events is presented as a matrix of risk ranks and a tool for analyzing project risks based on the matrix of risk ranks and FMEA analysis is developed.

Keywords: Standardization; risk; FMEA; change; project.

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1. Introduction

Nowadays the flow of container and rolling cargo in the Europe-Russian route of the Baltic sea region amounts up to 70% of Russian total volume of cargo transportation of this category. Russian ports handle only 27% of rolling cargo and 69% of container cargo; the rest are transported to the Russian Federation through neighboring states.

Building of multifunctional harbor transshipment complex (MHTC) "Bronka" in the Leningradskaya region as a part of a rolling cargo terminal capable of handling 260,000 units a year as well as building of a logistic center of supplementary services related to the handling of 90,000 units of cargo and 110,000 TEU a year and a container terminal with handling capacity of 1.9mio. TEU a year will allow reducing capacity shortage of Russian ports at the Baltic sea and meeting the demand for handling rolling and container cargo.

The project MHTC "Bronka" is in the situation of high uncertainty at present what results in the inability to forecast the results of the building. I. Fisher discusses several types of uncertainty in his work:

— objective uncertainty (shallowing of water area in our case);
— uncertainty related to the lack of sufficient relevant information (epistemic uncertainty);
— strategic uncertainty related to the dependence on the actions of other individuals (partners, competitors, state);
— uncertainty related to weakly structured problems (low quality of standardization);
— uncertainty related to the vagueness of phenomena and processes as well as of information describing them.

Uncertainty factors influencing the building process: external (weather conditions, interaction with government agencies, banks not able to meet financial obligations); internal (staff conflicts, equipment failures, resource provision failures).[1,3,4,7]

2. Methods

There are a lot of risk management approaches and methods, however, the problems of standardization influence on uncertainty and risks level as well as reduction of project realization terms have not been discussed yet. Using failure mode and effects analysis (FMEA) procedure (Table 1) we were able to find out nonconformities, their causes and effects.[1,5]

However, we should consider mutual influence of the problems. If we analyze mutual influence of potential nonconformities, we find out that climate change is a key problem determining project terms as well as amount of funding (Fig. 1). Considering this, we should change the model for calculation of risk priority number in our FMEA procedure to take into account such influence.[2,6,8]

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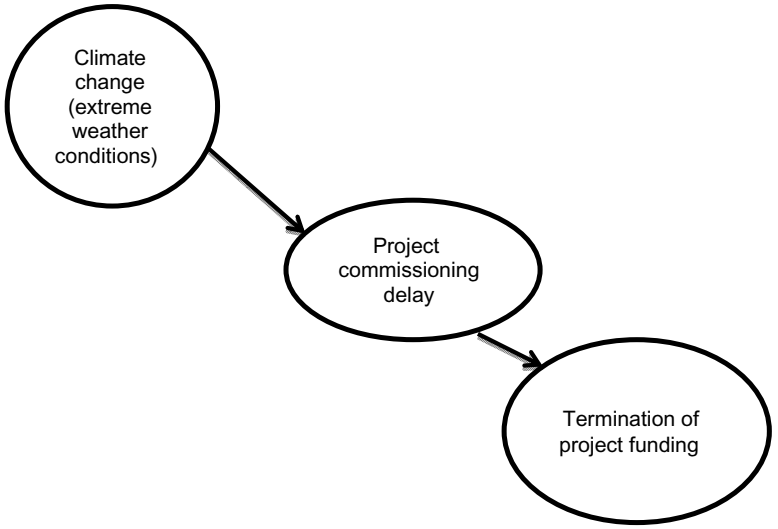

Fig. 1. Mutual influence of potential nonconformities.

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3. Suggested Changes in the FMEA Model

Figure 2 shows formulas for calculation of risk priority number (SOD) and for calculation of boundary value of SOD. Suggested improvements will allow developing corrective and preventive actions aimed not only at reducing not only the severity of a nonconformity with significant values of SOD but also at the frequency of dependent nonconformities.[9,10] Development of the so-called "simple knowledge database" for further creation of expert systems of data storage in an organization which will help personnel with less experience to find a description of a problem solution.

We shall give an example of SOD calculation (priority risk number) further. Figure 2 is of a generalized character; therefore, we should exemplify the use of the suggested method for an FMEA procedure.

3.1. *Nonconformities analysis*

In most cases, SOD is calculated using the following equation.

$$\text{SOD} = \max(S_1 \cdots S_i) \cdot O \cdot \max(D_1 \cdots D_j).$$

Let us consider the analysis of the potential nonconformity "Project commissioning delay".

To calculate SOD for the nonconformity "Project commissioning delay" (Table 1) we need to define the following values.

For index S we choose the value of 10 since it is the maximum value out of three values in the column "effect of a potential nonconformity". We explain that choice

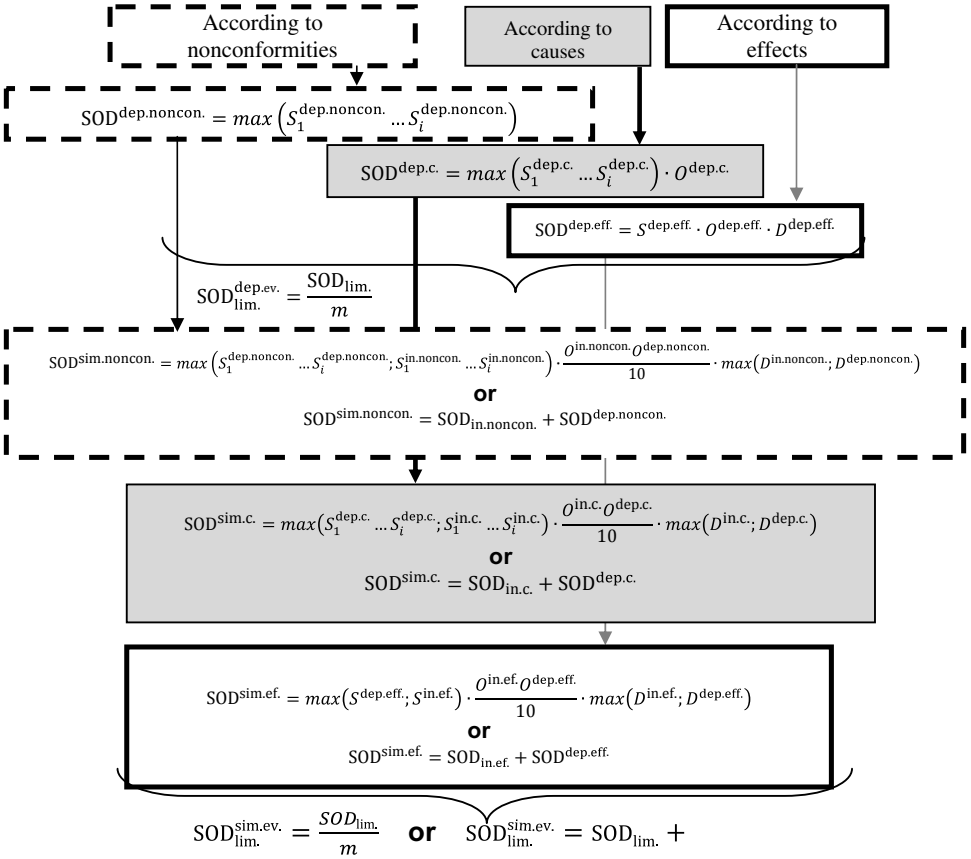

Fig. 2. Calculation of priority risk number.

Note: S – seriousness of effect; O – estimation of nonconformity frequency; D – nonconformity detection probability; dep. noncon.; dep. c.; dep. eff. - dependent nonconformity; dependent cause; dependent effect. in. noncon.;in.c.; in. ef. - independent nonconformity, independent cause and independent effect; SOD - priority risk number lim. - limit value which cannot be exceeded; sim. noncon.; sim. c.; sim.ef. - simultaneous (two or more) nonconformity; simultaneous causes or simultaneous effects. sim. ev. - simultaneous event (two or more nonconformities, causes or effects are simultaneous); dep. ev. - dependent event (nonconformity, cause or effect). m - coefficient considering resource limitation for elimination of two undesired events (default value is 2).

by the fact that it is necessary to consider the worst scenario during risk calculation (FMEA methodology), therefore we consider the most undesirable effects of a potential nonconformity (Table 1).

For index O we choose the only value indicated in Table 1, it is 2. It should be noted that these values are determined by experts who are familiar with the project under consideration. Index O informs that nonconformity "Project commissioning delay" takes place quite rarely.

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Table 1. Results of FMEA procedure for the project of MHTC.

Potential nonconformity	Effect of a potential nonconformity	S	Potential cause or mechanism of a nonconformity	O	Efficient measures to prevent the emergence potential causes	D	SOD	Actions taken
Project commissioning delay	Penal sanctions	5	Increased time uncertainties of the project	2	Uncertainty reduction	1	10	Interest of the government in the project
	Deterioration of international situation	10			Scientists involvement	3	60	Exchange of experience with international research communities
	Rating downgrade of the Russian Federation	10			Consideration of similar projects experience	4	80	Establishing contacts and exchange of experience with the companies in the same industry
Climate change (extreme weather conditions)	Water environment fauna extinction	7	Shallowing of the Gulf of Finland	5	Soils extracted from the seabed will be placed back	2	70	To find the place in the water area of the Gulf of Finland for soils transshipment using research studies
	Environmental pollution (discharge of sewage waters)	10			Building of supplementary sewage collectors	4	200	Increase sewage treatment degree up to 100%
Termination of project funding	Stop of the building process	10	Economic sanctions against the Russian Federation	2	Finding new investors	2	40	To interest investors in a project
	Deterioration of the regional economic situation	8			Involvement of Russian specialists (workers)	1	16	To establish mutually beneficial relations with higher education institutions
	Intensification of the crisis situation in the country	10			Import substitution of materials and equipment	1	20	Using domestic resources

Since the values of index D in Table 1 are related to effects, we choose the maximum value of index D (which is 4) considering the fact that the nonconformity "Project commissioning delay" can lead to any of three effects.

As a result, we obtain the priority risk number as follows:

$$\mathrm{SOD} = 10 \cdot 2 \cdot 4 = 40.$$

For such cases, the boundary priority risk number is 125. Therefore, we can say that the risk related to this nonconformity is not high because $40 < 125$.

3.2. *Analysis based on dependent nonconformities*

We know that the probability of the nonconformity "Termination of project funding" is substantially higher if the nonconformity "Project commissioning delay" also occurs. Thus, we need to change the risk calculation procedure for dependent nonconformities.

We suggest two equations for calculation of such risks.

$$\mathrm{SOD}^{\mathrm{sim.noncon.}} = \max(S_1^{\mathrm{dep.noncon.}} \cdots S_i^{\mathrm{dep.noncon.}}; S_1^{\mathrm{in.noncon.}} \cdots S_i^{\mathrm{in.noncon.}}) \cdot \frac{O^{\mathrm{in.noncon.}} O^{\mathrm{dep.noncon.}}}{10} \cdot \max(D^{\mathrm{in.noncon.}}; D^{\mathrm{dep.noncon.}})$$

or

$$\mathrm{SOD}^{\mathrm{sim.noncon.}} = \mathrm{SOD}_{\mathrm{in.noncon.}} + \mathrm{SOD}^{\mathrm{dep.noncon.}}$$

To calculate SOD according to these equations, we shall consider the data obtained from experts who determine the changes for S (seriousness of effects), O (frequency of events) and D (possibility of detection) for the nonconformity "Termination of project funding" for the case when the nonconformity "Project commissioning delay" occurs. Our experts found out that the value for S did not change, the value for O increased from 2 to 5 (Table 1) and the value for D did not change.

To determine S, we choose from the maximum values for "Penal sanctions" ($S = 5$), "Deterioration of international situation" ($S = 10$), "Rating downgrade of the Russian Federation" ($S = 10$), "Stop of the building process" ($S = 10$), "Deterioration of the regional economic situation" ($S = 8$), "Intensification of the crisis situation in the country" ($S = 10$). Choosing the maximum value, we obtain S equal to 10.

By O index calculation, we shall consider that index O will be 5 for "Termination of project funding"

The calculation

$$\frac{O^{\mathrm{in.noncon.}} O^{\mathrm{dep.noncon.}}}{10}$$

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Will be as follows

$$\frac{2 \cdot 5}{10} = 1.$$

Next, we shall choose the value for index D. To do that, we determine the maximum of "Uncertainty reduction" ($D = 1$), "Scientists involvement" ($D = 3$), "Consideration of similar projects experience" ($D = 4$), "Finding new investors" ($D = 2$), "Involvement of Russian specialists (workers)" ($D = 1$), "Import substitution of materials and equipment" ($D = 1$). As we can see, the maximum is 4.

Then

$$\mathrm{SOD}^{\mathrm{sim.noncon.}} = 10 \cdot \frac{2 \cdot 5}{10} \cdot 4 = 40.$$

But the boundary value for the risklevel, for which dependent events are considered, is not 125 but 62.5. It can be explained by the fact that more resources are required to control damage of two dependent events.

Calculation using the equation

$$\mathrm{SOD}^{\mathrm{sim.noncon.}} = \mathrm{SOD}_{\mathrm{in.noncon.}} + \mathrm{SOD}^{\mathrm{dep.noncon.}}$$

will be simpler but more exact. $\mathrm{SOD}_{\mathrm{in.noncon.}}$ in our example 40. That is a simple calculation for "Project commissioning delay". To determine $\mathrm{SOD}^{\mathrm{dep.noncon.}}$ we shall take into account that we changed the value of O index for "Termination of project funding" (it is 5, and not 2). Then,

$$\mathrm{SOD}^{\mathrm{dep.noncon.}} = 10 \cdot 5 \cdot 2 = 100.$$

The first figure is 10 because we chose the maximum for "Stop of the building process" ($S = 10$), "Deterioration of the regional economic situation" ($S = 8$),

Table 2. Subjects and roles of project participants.

Subjects - project participants	Participants' roles	Examples of criteria for refusing participation in the project	Examples if criteria for project promotion
Government	Control	Change of governmental priorities	Absent due to exclusively control function
International investors	Investment	Changes in legislation, sanctions, currency rate	Tax reduction or prolongation, potential profit increase
Russian investors	Investment	Changes in legislation, sanctions, currency rate	Tax reduction or prolongation, potential profit increase
Expert community (scientists)	Consulting	Lack of information about construction object	Possibility of obtaining new scientific results, provision of a project with innovative methods and technologies
Organization - leading contractor	Executive	Lack of investments	Coordination of investments with the program and terms, support of the government and local authorities
Outsourcers	Assisting	Lack of investments	Coordination of investments with the program and terms

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"Intensification of the crisis situation in the country" ($S = 10$). The second value is 5 because our experts determined that the value of O index change from 2 to 5 for "Termination of project funding" in case of project commissioning delay. The third value is 2 because we chose the maximum of "Finding new investors" ($D = 2$), "Involvement of Russian specialists (workers)" (D =1), "Import substitution of materials and equipment" ($D = 1$).

As a result, $\mathrm{SOD}^{\mathrm{sim.noncon.}} = 40 + 100 = 140$. The boundary value is 125 plus 62.5 and is equal to 187.5.

For practical calculations, any suggested method can be used. They allow taking into account the mutual influence of two undesirable events. Calculations for "According to causes" and "According to effects" (Table 2) can be carried out analogically.

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4. Analysis of Influence of a Subject Role on the Project Outcomes

Key characteristics of any project are its terms and implementation quality. According to quality management principles, control function belonging to the government increases project cost without influencing its value. Moreover, such role does not imply the responsibility for implementation terms what is the key reason for project implementation delay as well as for the fact that major projects are not implemented without governmental investments. We can conclude that it is necessary to consider roles of project participants and to change them if needed in order to implement a project adequately. In the discussed project, the government plays a control as well as an investment role. In this case, authorities responsible for funding the project of multifunctional harbor transshipment complex are interested in project implementation. That allowed finding governmental support in employing best experts and in using optimal technologies.

5. Standardization Influence on the Project Outcomes

Reconsideration of role functions influences project implementation terms. Obviously, refusing the control function is inappropriate; it is realized through legitimation of areas of responsibility and through involving independent experts. If a project is scientific-technical, implemented for the first time and requires involvement of the global scientific community to solve related problems (in our case this is water environment problem), speed of technological decision-making will depend not only on participants' roles, but also on standardization level. We mean that any standard answers the question "how to do?" i.e., standards are focused on providing procedures for activities, but they do not answer the question "why to do so?". However, scientific-technological projects require changes in calculation methods and performance assurance. It is found out that understanding the reasons for norms reduces the time for innovations implementation by 30% in average what is very important for projects.

Development of approaches to storing such information or, in terms of ISO 9000, management of such information is an important and actual task at present.

Models for requirements integration based on the theory of sets. When developing regulatory documents for an organization we deal with norm interaction in cases, when integration of several requirements of international standards, other regulatory documents or customer requirements is necessary. We represent such norm integration using the theory of sets (including fuzzy sets) (Table 3).

We can conclude from this illustration that there are four types of norm interaction in the process of integration: fusion, crossing, addition and negation. If norm interaction tend to be of an addition or negation types, norm integration is not required or impossible, respectively. Negation often takes place in the interaction of requirements of different countries as our example shows. This situation can be exemplified by the case of norm inconsistency for airstairs installation. In practice, the personnel of standardization departments are forced to "inherit" all norm conflicts into the documents of the next generation.[10–13] Such situation results in 100% violation of requirements of a regulatory document. Solution of such conflicts is possible only if we know the reasons for norm introduction.[14–17] When the reasons for norm introduction are known, it will be possible to determine priorities and situations (areas of application) for using one or other norm.

Model of norm interaction and development. When we discuss norm inheritance, we can draw an analogy of this process with the process of gene inheritance in biology. Development and implementation of new norms is always connected to the efforts to manage some chaotic situation as well as to optional (reasoned) or nonoptional (not reasoned) new state of system equilibrium,[18,19] i.e., introduction of a new norm changes work relations. To apply the models we need to define the following notions. Norm emergence is a standardization process of a new activity or a new product. Norm progress is development and distribution of a norm, its adjustment to other requirements. Norm regress is reduction of the area of norm application or its transformation to optional requirements. Norm competition is a situation when several requirements are in conflict ("mutual negation"). Norm homoeostasis is an equilibria interaction with other requirements.

Let $k_1(S)$ be a coefficient of entropy production in a system, $L_1(S, n)$ — function of system reaction to a problem, $k_2(S, n)$ — function showing a reaction to a new

Table 3. Analysis of norm interaction.

Types of norm interaction	Illustration	Formula
Integration	If A={1,2,4}, B={3,4,5,6}, A ∪ B={1,2,3,4,5,6}	C=A ∪ B
Intersection	If A={1,2,4}, B={3,4,5,2}, A ∩ B={2,4}	C=A ∪ B
Addition	A={1,2,4}, B={1,2,4}	A=B B=A
Negation	If A={1,2}, B={3,4,5}	A Δ B

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norm introduction, $L_2(n)$ — coefficient of norm amortization. Dependence $L_1(S, n)$ on n is related to the fact that the rate of entropy reduction depends nonlinearly on inheritance due to the limits of system resources and therefore its inheritance. If inheritance increases entropy reduction rate decreases, but it cannot be negative. We suggest to consider the rate $k_2(S, n)$ as inheritance-dependent since inheritance rate increase depends not only on the problems in a system, but also on inheritance level. These functions are continuous and situated on the positive semi-axis n, $S \geq 0$. Let us consider the following model:

$$dS/dt = k_1(S)S - L_1(S, n)n,$$

$$dn/dt = k_2(S, n)S - L_2(n)n.$$

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We shall describe this model in a number of assumptions.

(1) Inheritance is a result of system functioning in the process of solving production problems. The coefficient of inheritance increase $k_2(S, n)$ depends on entropy and inheritance which a system possess. Inheritance decreases due to regress and competition. Rate of decrease is proportional to inheritance amount with the coefficient $L_2(n)$ depending only on inheritance.
(2) Entropy production is equal to the rate of production problems emergence with production rate $k_1(S)$ dependent only on entropy. Entropy decrease is provided by solving the problems with a certain coefficient dependent on chaos and inheritance levels of the system $L_1(S, n)$.
(3) For the states of emergence and progress partial derivative function describing reactions at intervention satisfy inequalities $dk_2/dS > 0, k_2(0, n) \leq 0 < k_2(\infty, n)$ because zero level of entropy implies absence of problems and therefore inheritance is stable or decreases. The rate of inheritance production increases with increase of entropy and changes from negative (when there was no inheritance at the moment of norm emergence) to positive values. For the state of competition $L_1(S, n) < 0$ when $S > 0$, $n > 0$; $L_1(0, n) = 0$ and $L_1(S, 0) = 0$. For the state of regress the function of reaction $L_1(S, n) > 0$ when $S > 0$. For the state of homoeostasis $L_1(S, n) = 0$.

If we see at solution of the models, we can conclude that after some period a system will collapse but will retain a certain part of inheritance. That means that a certain part of developed norms will be inherited by a new production system after collapse of an old system.[20,21] For example, a norm can transform from a technological norm to a corporative norm.

Methods for assessment of norm integration possibility. It can be seen that norm integration is a complex task requiring a large amount of preparation work. Let us demonstrate an algorithm for normative requirements integration (Fig. 3).

Forming of a metalanguage includes assessment of term databases of two documents and development of a unified glossary which will be clear for a production system. Development of statistic linguistic system aims at creation of standards

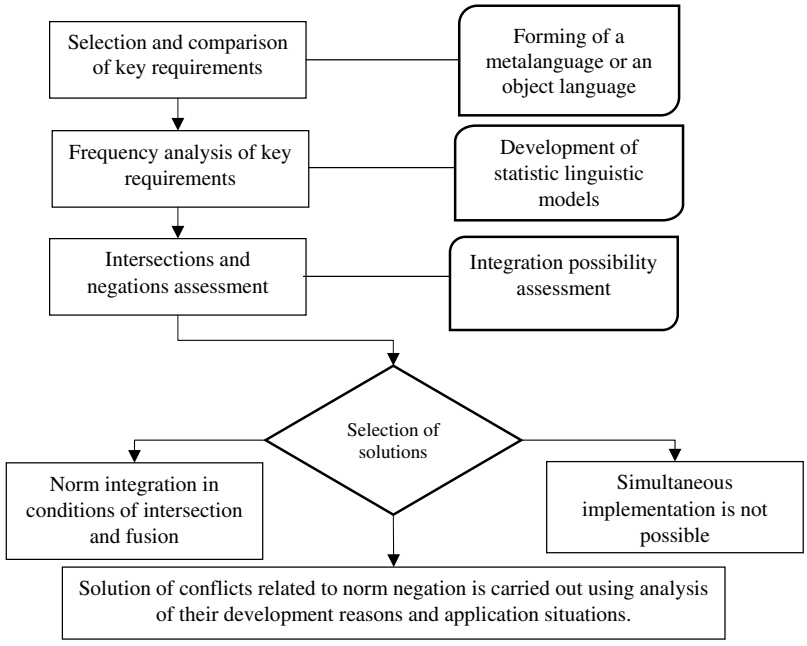

Fig. 3. Algorithm for normative requirements integration.

in a digital form when each requirement corresponds to a number which reflects the importance of a requirement. The described model allows assessing priorities of standards to be integrated (Fig. 3).

Unfortunately, we should note that not all standards can be integrated. There are situations when simultaneous application of different requirements is not possible. Frequently it is connected with conflicts of assessment methods, for example calculation of strength or other types of calculation.

6. Conclusion

In the process of project realization, attention is always paid to its quality and speed of implementation. To meet the requirements of these parameters it is necessary to improve procedures of uncertainty and risk analysis as well as standardization principles. When applying FMEA method we should consider mutual influence of problems what changes the methods for priority risk number calculation substantially. The roles of project subjects influence its implementation, especially in control procedures. If in the process of project implementation it is necessary to change established technical norms, one should analyze reasons for norm development and areas of its application, but the problem of modern standardization is in the fact that it answers the question "how to do?" rather than the question "why to do so?". That means that there is no practice of storing information about reasons of norm development. For detailed analysis of integration, possibility

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development of statistic linguistic model of normative documents is necessary. Modeling of norm interaction and development shows that there is a certain process of norm inheritance by different production systems, so a norm can transform into a tradition.

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